MICROBIOLOGICAL ASPECTS OF FRUIT JUICES

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JOSEPH FORGACS

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SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
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MICROBIOLOGICAL ASPECTS OF FRUIT JUICES

Popularity of fruit juices has increased during recent years. Several problems have been raised at various times by food control and health officials. Since unclean water may be used for washing apples to be pressed, it is desirable to know whether pathogenic bacteria can remain viable for any period of time in apple juice. Juice is often frozen and thawed to extend the marketing season. Data on effects of freezing in large, commercial-sized containers such as gallon jugs are entirely lacking. Clouding of apple juice is a serious problem and it is interesting to study this condition.

Research concerned with longevity of *Eberthella typhosa* in normal cider probably dates back to 1898 when Bodin observed cells of this organism to decrease from 1¼ million to 51,400 in 24 hours. Douglas and Edin (1930) found pH to be important in destruction of typhoid organisms. Although considerable reduction in the original number of microorganisms was observed, Tanner and Wallace (1931) found living microorganisms in many frozen fruits and vegetables. McFarlane (1940) observed greater decrease in microorganisms in apple juice at —20°C (—4°F) than in juice held at —10°C (14°F). That acids differed in germicidal value was reported by Erickson and Fabian (1942). Temperatures recommended for flash-pasteurization of apple juice, varied from 160° to 190°F (71° to 88°C), according to various workers; although these temperatures are not sufficient to destroy all organisms, those remaining are unable to cause spoilage of the product, according to these workers. Tanner (1932) reported ropiness in uncanned apple juice owing to growth of certain organisms. Townsend (1939) reported a group of organisms closely related to *Clostridium pasteurianum* Winogradsky responsible for spoilage of low acid canned fruits and tomatoes. Spiegelberg (1940) found six types of bacterial swells in spoiled pineapple; one type was identified as *Clostridium pasteurianum* Winogradsky.

Clouding of juice, according to various workers seems to be associated with changes of pectin. Of great interest in this connection are data reported by Kertesz (1936, 1937), Tressler and Pederson (1936), Pederson and Tressler (1938), Arengo-Jones (1940-1941), Neubert (1943), and Marshall (1943).

Longevity of *Escherichia coli, Eberthella typhosa, Salmonella aertrycke, Salmonella schottmülleri,* and *Salmonella paratyphi* was determined in apple juices varying in pH, total titrable acidity, tannin, and total solids, at ordinary room temperature, at 5°C (41.1°F) and —16°C (3.2°F). In addition, effects of clarification by filtration through diatomaceous earth and of pasteurization of clarified juice at 81.1°C (178°F) were studied. Wilson and Blair's bismuth-sulfite agar was used for culturing. A small laboratory-model, glass flash-pasteurizer was devised and used.

It was observed: (a) Death rate at the three temperatures was logarithmic. (b) *Escherichia coli* in a cloudy Grimes juice and *Eberthella typhosa* in a clear Jonathan juice decreased more rapidly at —16°C than at 5°C and least at room temperature. *Salmonella aertrycke* in Grimes juice decreased more rapidly at —16°C and least at 5°C; *Escherichia coli* was more resistant than *Salmonella aertrycke* in the same juice. (c) Juice to which tannin and malic acid had been added was considerably more bactericidal than untreated juice. (d) Although Duchess juice had a lower pH and greater total acidity than juice to which tannin and malic acid had been added, it was less bactericidal. probably because of its lower tannin content. (e) Processing altered the bactericidal property of apple juice.

Effects of alternate-freezing and thawing and of varying the time of thawing upon pH, total acidity, refractometer reading and microflora of various apple juices frozen in gallon jugs were observed. For microbiological analysis, dextrose agar was used as the culture medium.

It was found: (a) An increase in acidity and hydrogen-ion concentration occurred. (b) The refractometer reading (a rough estimate of per cent sugar) decreased. No constant correlation existed between refractometer reading and total acid content or pH. (c) Death rate of microorganisms, in general, was more rapid in juices thawed for 17 hours and refrozen every two weeks, than in those thawed for 24 hours and refrozen every week. (d) In juices thawed 17 hours, death rate was the slowest in Delicious and Golden Delicious juices which were considerably less acid than others used. (e) Absolute sterility was obtained in only a few cases, although total number of microorgan-

isms decreased greatly in most juices. (f) Order of dominance of microorganisms at the end of the investigation was gram-positive rods, gram-negative rods, cocci and yeasts. (g) Most juices thawed and refrozen were unsuitable for human consumption when the investigation was discontinued.

Several varieties of canned apple juices stored at ordinary room temperatures for 2 years were examined chemically and microbiologically. Gram strains, hemacytometer counts, and aerobic and anaerobic plates were made. In addition, pH and total acidity were determined. Dextrose agar was used as the standard medium and Marino's plates were used for determining presence of anaerobes. Clouding was also studied in a limited way. Some cans were normal in appearance, others were springers and flippers.

The following was found: (a) Change in pH and total titrable acidity at the end of the experiment was observed, however, no correlation existed. Hydrogen-ion concentration decreased and acidity increased. Refractometer reading decreased. (b) Pitting was observed in swelled and normal cans. The extent of pitting varied, but, it was confined mostly to the seam and bottom. (c) Different types of microorganisms were found, many of which grew on common laboratory media. On the basis of a random selection of colonies growing aerobically on dextrose agar, rod-shaped bacteria prevailed. (d) Clouding was observed in many cases which was not directly accounted for. On the basis of results obtained an anaerobic growth may be responsible, at least in part, for clouding of apple juice.

Literature Cited

Arengo-Jones, R. W., 1940. The preparation and preservation of apple juice. Fruit Products Journal, **19**, 327-330; 356-358; 375; 377. **20**, 7-9; 23; 47-51.

———— 1941. The preparation of fermented ciders. Fruit Products Journal, **20**, 300-308; 321; 338-339; 353; 355; 372-377.

Bodin, E., 1898. Sur la conservation du bacille typhique dans le cidre. Ann. de L'Inst. Pasteur, **12**, 458-464.

Douglas, M. and Edin, M. D., 1930. Some principles regulating the life and death of pathogenic intestinal bacteria in artificial media and fruit juices. Lancet, **219**, 749-791.

Erickson, F. J., and Fabian, F. W., 1942. Preserving and germicidal action of various sugars and organic acids on yeast and bacteria. Food Res., **7**, 68-79.

Marino, F., 1907. Methode pour isoler les anaerobies. Ann. de L'Inst. Pasteur, **21**, 1005-1008.

Marshall, R. E., 1943. Prevention of precipitation in processed apple juice. Fruit Products Journal, **23**, 40-42.

McFarlane, V. H., 1940. Behaviour of microorganisms at subfreezing temperatures. I. Freezing redistribution studies. Food Res., **5**, 43-47.

Neubert, A. M., 1943. Effect of filtration on appearance, viscosity, and alcohol-insoluble fractions of apple juice. Food Res., **8**, 447-488.

Pederson, C. S., and Tressler, D. K., 1938. Flash pasteurization of apple juice. Ind. Eng. Chem., **30**, 954-959.

Spiegelberg, C. H., 1940. Some factors in the spoilage of an acid canned fruit. Food Res., **5**, 439-455.

Tanner, F. W., 1932. Microbiology of foods. First ed., 321. Twin City Printing Company, Champaign, Illinois.

Tanner, F. W., and Wallace, G. I., 1931. Effect of freezing on microorganisms in various menstrua. Proc. Soc. Expt. Biol. and Med., **29**, 32-33.

Townsend, C. T., 1939. Sporeforming anaerobes causing spoilage in acid canned foods. Food Res., **4**, 231-237.

Tressler, D. K., and Pederson, C. S., 1936. The pasteurization of apple juice. New York (Geneva) Sta. Agr. Expt. Sta. Cir. 181, 1-16.

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1941 Results from one year's investigation with apple juice. Proc. Ill. Sta. Hort. Soc., **75,** 103-117 (with R. V. Lott)

1941 Importance of cleanliness in production of apple juice. Proc. Ill. Sta. Hort. Soc., **75,** 239-246

1942 A microbiological analysis of apple juice processing. Food Research, **7** (6) 442-450

1943 Longevity of pathogenic bacteria in apple juice. Fruit Products Journal, **22** (10) 295-299, 304 (with F. W. Tanner)

1943 Effect of apple juice on typhoid organisms. Illinois Horticulturist, **32,** (1), 5-6

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